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Twenty-one cognitive abilities, ease with which the speaker is lipread, structure of the language lipread, age and education of the lipreader and sex were hypothesized as being important in lipreading. Three factor analyses were conducted of lipreading variables and cognitive abilities in order to verify or refute the hypotheses. The influence of age and/or education on factor structure was also examined. Three samples of hearing lipreaders were used in the investigation: 89 eighth graders, 60 eleventh graders, and 102 adult females. The factoral analyses isolated seven lipreading factors: general lipreading ability, word-phrase lipreading ability, lipreading reasoning, facility with language, word facility, figural word fluency, spatial detail. Important cognitive abilities in lipreading are fluency and perceptual abilities. Reasoning and flexibility abilities, although of lesser importance than fluency and flexibility abilities, were also found to be important in lipreading. The findings have implications for lipreading teaching. It is suggested that this study has demonstrated the value of factor analysis in the study of lipreading and it is recommended that further factor analytic investigations of lipreading be undertaken. (Author/JD)

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An Investigation of the Cognitive Domain of Lipreading

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Gordon Taaffe

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University of Detroit

Detroit, Michigan

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Gordon Taaffe

An Investigation of the Cognitive Domain of Lipreading[1]

INTRODUCTION

Problem and Background

The problem of this investigation is to define the structure of lipreading. Logical analysis of lipreading suggests that lipreading is a communication process requiring visual abilities and basic competencies in the language lipread. Study of the visible movements of articulation reveals however that much of what is said produces no facial or mouth movements. So, in addition to knowledge of the structure of language and visual abilities, it would appear that success in lipreading must also require reasoning powers with which to fill in missing elementsin the lipread stimulus. This added operation in lipreading suggests that in addition to the abilities and knowledge just mentioned, the lipreader must also use memory abilities with which to hold in storage visual cues while he matches them with appropriate language in fashioning his lipread message and that the lipreading act must be accomplished rather quickly. This logical analysis then suggests that verbal, visual, reasoning, memory and rapidity-of-thinking abilities are important in lipreading. The problem and hence the experimental investigation, is to obtain verification of this logical analysis.

Review of Related Literature

Many hearing people with no formal training in lipreading, can lipread quite well when tested for the first time (31, 48, 59). In this regard, many groups

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[1]Report based on a doctoral dissertation. The complete study with associated tables is available through University Microfilms.

of hearing people not formerly trained in lipreading, lipread better on the average than do groups of hearing impaired who have had formal lipreading instructions (48, 51). A summarization of research findings about lipreading shows that both the hearing and the deaf, the intelligent and the mentally retarded, the very young and the aged, male and female all have substantial representation among competent lipreaders (14, 16, 32, 47, 48, 50). It would appear that skill in lipreading is associated with formal educational progress and with sex (48). College students lipread better, on the average, than do high school students; high school students lipread better than grammar school lipreaders; teachers of the deaf are, on the average, the best lipreaders. Women are typically better lipreaders than men (14, 15, 16, 48, 58). Other studies of lipreading suggest that while training in lipreading does aid in developing one's skill in this area, increasing one's native ability in lipreading through formal lipreading training is a difficult and slow process (51, 58).

Differences among speakers makes a difference in the efficiency with which a lipreading sequence is interpreted, but Taafe and Wong (51) have shown that performance on face-to-face lipreading with different speakers, different sequences of filmed speakers, with and without context, in black and white and in color, are highly intercorrelated. The average score for the group varied from one medium to another, suggesting that one medium was more difficult than another, but the relative ranking with respect to lipreading performance was constant for individual lipreaders with the various mediums of presentation (6). Stone (46) has shown that the more of a speaker that is visible to the lipreader, the better lipreading will be. In this study, a mask was prepared to obscure all but the speaker's lips for one experimental condition; a second experimental condition presented the speaker with chin to nose exposed; a third condition showed the speaker's face from chin to eyebrows and the final experimental condition presented the speaker's head and upper torso.

The relationship was not linear but there were significant increments in lipreading performance as more and more of the speaker was exposed to the lipreader.

Woodward (59, 60) has shown that labial phonemes are discriminated most efficiently and suggests that the term "lipreading" is perhaps well taken though some people prefer "speech reading," or "visual speech hearing" as more descriptive of the lipreading process. Woodward has also shown that lipreading of a filmed speaker is most efficient when the speaker is photographed 45° off center (59).

Experimental studies of lipreading have been conducted using phonemes, syllables, word lists, phrases, sentences and stories. Most lipreading tests require the lipreader to write down what he thinks has been said and the lipreader is commonly credited with one point towards his total score for each word (or other element) correctly recorded. Language elements, particularly words, are uneven measures of lipreading however in that words differ in lipreading difficulty and the same word may differ in difficulty depending on its linguistic environment. Despite the unevenness of the unit of measurement, reported internal consistency and test retest reliabilities of lipreading tests are usually high.

Studies of aptitudes, temperament, intelligence, and academic achievement of deaf subjects are legion. There is not uniformity of agreement concerning the results of these investigations however with the exception that the education of the deaf is considered to be an extremely difficult educational process and that lipreading is believed to require a "synthesizing" ability. Studies of lipreading have been conducted using face-to-face lipreading and filmed and televised speakers with both deaf and hearing subjects (4, 7, 19, 22, 48, 53, 59, 60). The results suggest that lipreading is a general behavioral phenomenon, that is to say, everyone who has a language can lipread with more or less precision and some individuals, irrespective of their hearing loss or formal training in lipreading, can lipread quite well.

Hypotheses and Model

Hypotheses The abilities hypothesized to be important in lipreading are in the general areas of verbal, perceptual, visual, memory and reasoning. With respect to specific hypotheses, 21 cognitive abilities were hypothesized as being important in lipreading. These cognitive abilities are described in Table 1. Thirty-four tests were employed to measure the cognitive abilities. Ten abilities have a single test measuring the ability; nine abilities have two tests measuring the ability and three tests each were used to measure two cognitive abilities. Selection of tests to measure an ability was based on the importance of the ability to the study, on the test's reliability or adequacy to measure the ability, and on availability of cognitive-ability tests generally. It was planned to introduce part scores (part I and part II) for the single measures of abilities in order to enhance the possibility of isolating the ability in subsequent factor analyses.

Criterion measures of lipreading are also presented in Table 1. It will be noted that nine lipreading variables are listed. The nine variables were obtained from three lipreading tests (three scores from each test). The lipreading tests incorporate two experimental conditions. One condition is ease and difficulty with which a lipreader lipreads a speaker. For example, each test contains an easy-to-lipread speaker, a speaker of average difficulty to lipread and a difficult-to-lipread speaker. The lipreading test series is comprised of a word, a phrase and a sentence lipreading test. The sentence lipreading test was prepared first, phrases taken from the sentence lipreading test were used to make up the phrase lipreading test and words taken from the sentence lipreading test were used to compose a word lipreading test. The second experimental condition incorporated into the study was structure of language as a variable in lipreading. By using the same language elements in all of the lipreading tests, it was hoped to hold constant lipreading difficulty due to language.

TABLE 1

Cognitive Abilities, Tests of Cognitive

Abilities and Lipreading Variables

Cognitive Ability: Flexibility of Closure

Description of Ability: The ability to keep one or more definite configurations in mind so as to make identification in spite of perceptual distractions.

Tests used to measure ability:
1. Hidden Patterns
2. Copying Test

Cognitive Ability: Speed of Closure

Description of Ability: The ability to unify an apparently disparate perceptual field into a single percept.

Tests used to measure ability:
3. Gestalt Completion Test
4. Concealed Words Test

Cognitive Ability: Associational Fluency

Description of Ability: The ability to produce words from a selected area of meaning.

Tests used to measure ability:
5. Associational Fluency

Cognitive Ability: Expressional Fluency

Description of Ability: The ability to think rapidly of appropriate wording for ideas

Tests used to measure ability:
6. Simile Interpretation
7. Word Arrangements

Cognitive Ability: Ideational Fluency

Description of Ability: The facility to call up ideas wherein quantity and not quality of ideas is emphasized

Tests used to measure ability:
8. Topics Test
9. Thing Categories Test

Cognitive Ability: Word Fluency

Description of Ability: Facility in producing isolated words that contain one or more structural, essentially phonetic, restrictions, without reference to the meaning of the words.

Tests used to measure ability:
10. Word Beginnings and Endings Test

Cognitive Ability: Induction

Description of Ability: Associated abilities involved in the finding of general concepts that will fit sets of data, the forming and trying out of hypotheses.

Tests used to measure ability:
11. Locations Test
12. Figure Classification

Cognitive Ability: Length Estimation

Description of Ability: Ability to judge and compare visually perceived distances on paper.

Tests used to measure ability:
13. Estimation of Length Test
14. Shortest Road Test
15. Nearer Point Test

Cognitive Ability: Associative (rote) Memory

Description of Ability: The ability to remember bits of unrelated material.

Tests used to measure ability:
16. First and Last Names Test

Cognitive Ability: Memory Span

Description of Ability: The ability to recall perfectly for immediate reproduction a series of items after only one presentation of the series.

Tests used to measure ability:
17. Digit Span - Visual

Cognitive Ability: Perceptual Speed

Description of Ability: Speed in finding figures, making comparisons, and carrying out other simple tasks involving visual perception.

Tests used to measure ability:
18. Finding A's
19. Number Comparison

Cognitive Ability: General Reasoning

Description of Ability: The ability to solve a broad range of reasoning problems including those of a mathematical nature.

Tests used to measure ability:
20. Ship Destination Test

Cognitive Ability: Numerical Ability

Description of Ability: The ability to manipulate numbers in arithmetical operations rapidly.

Tests used to measure ability:
21. EAS #2 Numerical Ability.
22. Arithmetic Operations Test

Cognitive Ability: Semantic Redefinition

Description of Ability: The ability to shift a function of an object and use it in a new way.

Tests used to measure ability:
23. Gestalt Transformation
24. Object Synthesis

Cognitive Ability: Syllogistic Reasoning

Description of Ability: Ability to reason from stated premises to their necessary conclusions.

Tests used to measure ability:
25. Nonsense Syllogisms
26. Logical Reasoning

Cognitive Ability: Spatial Orientation

Description of Ability: The ability to perceive spatial patterns or to maintain orientation with respect to objects in space.

Tests used to measure ability:
27. Cube Comparison Test

Cognitive Ability: Spatial Scanning

Description of Ability: Speed in exploring a wide or complicated spatial field.

Tests to measure ability:
28. Maze Tracing Speed Test

Cognitive Ability: Verbal Comprehension

Description of Ability: The ability to understand the English Language.

Tests to measure ability:
29. Wide Range Vocabulary Test

Cognitive Ability: Visualization

Description of Ability: The ability to manipulate or transform the image of spatial patterns into other visual arrangements.

Tests used to measure ability:
30. Form Board Test
31. Paper Folding Test
32. Surface Development Test

Cognitive Ability: Figural Adaptive Flexibility

Description of Ability: The ability to change set in order to meet new requirements imposed by figural problems.

Tests used to measure ability:
33. Match Problems V

Cognitive Ability: Semantic Spontaneous Flexibility

Description of Ability: The ability to produce a diversity of verbally expressed ideas on a situation that is relatively unrestricted.

Tests used to measure ability:
34. Utility Test

Cognitive Ability: Word Lipreading Ability

Description of Ability: The ability to lipread unrelated words.

Tests used to measure ability:
1st 10 words, Word Lipreading Test, easy-to-lipread speaker

Cognitive Ability: Word Lipreading Ability

Description of Ability: The ability to lipread unrelated words.

Tests used to measure ability:
2nd 10 words, Word Lipreading Test, difficult-to-lipread speaker

Cognitive Ability: Word Lipreading Ability

Description of Ability: The ability to lipread unrelated words.

Tests used to measure ability:
3rd 10 words, Word Lipreading Test, average difficult-to-lipread speaker

Cognitive Ability: Phrase Lipreading Ability

Description of Ability: The ability to lipread unrelated phrases.

Tests used to measure ability:
1st 10 phrases, Phrase Lipreading Test, difficult-to-lipread speaker

Cognitive Ability: Phrase Lipreading Ability

Description of Ability: The ability to lipread unrelated phrases.

Tests used to measure ability:
2nd 10 phrases, Phrase Lipreading Test, average difficult-to-lipread speaker

Cognitive Ability: Phrase Lipreading Ability

Description of Ability: The ability to lipread unrelated phrases.

Tests used to measure ability:
3rd 10 phrases, Phrase Lipreading Test, easy-to-lipread speaker

Cognitive Ability: Sentence Lipreading Ability

Description of Ability: The ability to lipread unrelated sentences.

Tests used to measure ability:
1st 10 sentences, Sentence Lipreading Test, average difficult-to-lipread speaker

Cognitive Ability: Sentence Lipreading Ability

Description of Ability: The ability to lipread unrelated sentences.

Tests used to measure ability:
2nd 10 sentences, Sentence Lipreading Test, easy-to-lipread speaker

Cognitive Ability: Sentence Lipreading Ability

Description of Ability: The ability to lipread unrelated sentences.

Tests used to measure ability:
3rd 10 sentences, Sentence Lipreading Test, difficult-to-lipread speaker

It was further hypothesized that age and/or education was influential in lipreading as was sex. In summary, the variables hypothesized to be important in lipreading were:

Twenty-one cognitive abilities
Ease and difficulty with which the speaker is lipread
Structure of the language lipread
Age and/or education of the lipreaders
Sex

Experimental Model In designing the approach to be followed in this investigation several experimental conditions were considered. Of paramount importance was that lipreading be considered as a systems analysis, and that all elements in the system be controlled while a particular element was under study. For example, a lipreader, a communication channel, and a speaker are in the system. Also in the system is a message transmitted over the system from speaker to lipreader. Each element in the system offers variables for study, but the entire system must be held constant while a particular element is systematically varied. In this investigation it was planned to put the lipreader under intensive analysis while the lipreading stimulus material was either held constant or systematically varied.

A fundamental consideration was how best to isolate lipreading ability into its constituent specific abilities when physical isolation of components of lipreading would render this communication process meaningless. Factor analysis however is ideally and perhaps uniquely suited for the analysis of lipreading. Factor analysts have isolated a wide variety of human abilities and developed measures of them. The application of factor analysis to the analysis of lipreading is timely.

A third problem in studying lipreading is the appropriate medium of speaker presentation to use in

assessing lipreading ability. Face-to-face lipreading is the typical lipreading situation. Face-to-face lipreading leaves much to be desired experimentally however. Filmed speakers have proved themselves to be both valid and reliable as criterion measures of lipreading by this and other investigators and they hold presentation of lipreading stimulus material constant from one presentation to another (10, 17, 18, 19, 22, 24, 28, 31, 46, 48, 53). Because of the inherent experimental advantage to be gained in using filmed speakers, motion picture lipreading testing as the criterion measurement of lipreading was adopted by the investigator.

A fourth problem in the investigation of lipreading is the choice of lipreaders with respect to hearing-impairment. There are several cogent reasons for using normally hearing subjects for an initial investigation of cognitive abilities important in lipreading. For one thing, repeated studies have shown that hearing people can lipread when tested for the first time. At the same time, homogeneous samples of hearing people with respect to academic development and it is assumed, development of cognitive abilities are easily obtained. Group lipreading testing of hearing subjects presents no particular problem. Finally, the lipreading protocols of hearing subjects are not apt to be erroneously scored for grammatical error instead of lipreading error. Controlling for vicarious lipreading experience of hearing subjects can be controlled by controlling for age.

On the other hand, samples of hearing-impaired lipreaders with respect to age-at-onset of deafness, amount of lipreading training, comparability of academic achievement, and many other factors associated with the deaf, makes a study based on them difficult of interpretation. The possibility of penalizing the deaf lipreader because of faulty grammatical structure in his lipreading protocol instead of failure to lipread mitigates against the use of hearing-impaired subjects as does the administrative problems incurred in testing the deaf.

The question of whether a study of lipreading based on samples of hearing subjects is generalizable to deaf populations is similar to the question of whether a study of grammar based on normally hearing students can be generalized to the deaf students. The answer is no; not completely. The language structure for the two samples is different. However there is much about the hearing person's grammar that can be generalized to language structure of the deaf and what is true for language structure should be true for lipreading. It was felt that the present study could serve as a point of departure for rigorously controlled studies with hearing-impaired subjects but that this study with hearing subjects should precede a study with deaf subjects.

In summary, the experimental design calls for the presentation of lipreading stimulus material together with tests of cognitive abilities to groups of lipreaders. Measures of lipreading will be correlated with measures of cognitive abilities and the resulting correlation matrix, factor analyzed. The procedure puts both the dependent and independent variables in the same factor matrix. Tests of cognitive abilities loading significantly with measures of lipreading on a factor will be used to describe lipreading ability. While the major objective of the study is to isolate and describe lipreading ability, the influence of selected experimental variables on the factor structure of lipreading will be also examined. The selected experimental variables are structure of the language lipread, ease and difficulty with which the speaker is lipread, sex and age and/or education.

Method

Cognitive Abilities Permission was granted to reproduce aptitude tests in a Kit of Cognitive Abilities (6) published by Educational Testing Service. J. P. Guilford (8) also granted permission to reproduce certain Structure-of-Intellect tests. Four aptitude tests were purchased from commercial vendors. The measures of the cognitive abilities, or aptitude tests, were reproduced in sufficient numbers to satisfy sample requirements and put together in the form of nine test booklets, of approximately 40 minutes test administration time each. Total testing time for the complete battery was six hours.

Lipreading Variables A Word Lipreading Test, a Phrase Lipreading Test and a Sentence Lipreading Test were prepared as The Detroit Lipreading Tests. Three speakers narrated a third of each test. For example, the easy-to-lipread speaker narrated the first ten words contained in the Word Lipreading Test; the difficult-to-lipread speaker narrated the second ten words and the speaker of average difficulty to lipread narrated the third ten words. In a similar way, the three speakers narrated a third of each of the two remaining lipreading tests. Order of appearance of the speakers in the three films was varied according to a latin square design to minimize order-of-appearance influences in lipreading. The organization of the Lipreading Tests afforded the experimenter nine lipreading variables. That is to say, a lipreading score was obtained for each speaker in each test. The organization of the Detroit Lipreading Tests is presented in Table 2.

Table 2

Organization of the Detroit

Lipreading Tests

Word Test	Phrase Test	Sentence Test
10 Words (E)[1]	10 Phrases (D)	10 Sentences (A)
10 Words (D)	10 Phrases (A)	10 Sentences (E)
10 Words (A)	10 Phrases (E)	10 Sentences (D)
30 words	30 phrases	30 sentences
8 minutes	12 minutes	16 minutes

[1] (E) easy-to-lipread speaker
(D) difficult-to-lipread speaker
(A) average difficulty-to-lipread speaker

Sample Population Lipreading and cognitive ability test administration was conducted over a six month period at a local junior high school (eighth grade sample), at a local high school (eleventh grade sample) and at two local colleges which educated nuns. Attrition of subjects was high due to an examinee missing one or more tests in the junior high and high schools. The composition of the same population included in the factor analytic studies is:

Eighth grade sample, 49 boys and 40 girls, total 89 subjects
Eleventh grade sample, 27 boys and 33 girls, total 60 subjects
Adult female sample, 102 adult females

All were hearing subjects with no history of hearing or visual impairment and no history of lipreading instruction.

Data Preparation and Analysis The aptitude and lipreading tests were scored, and scores prepared for factor analysis by computer.[1] Pearson product moment coefficients of correlation were used to intercorrelate aptitude test variables. Phi coefficients were used to intercorrelate the lipreading variables. The lipreading score distributions were skewed necessitating a dichotomous correlation technique and phi's were favored over tetrachoric coefficients of correlation because of the more stable relatibility of the phi over the tetrachoric coefficient. Aptitude-lipreading correlations were computed by bi-serial coefficients of correlation and sex, where it was included as a variable, was computed by point bi-serial coefficients of correlation with aptitude tests and by phi coefficients with lipreading.

Principle component factors were extracted and rotated to simple structure and positive manifold by verimax procedures.

The nine lipreading variables were factor analyzed apart from the aptitude tests and then factor analysis was conducted on the data of the three samples for the entire battery of tests (cognitive and lipreading tests).[2]

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[1]Bureau of Educational Research, Kent State University, Philip R. Merrifield, Director.

[2]Rotated and unrotated factor matrices are presented in the dissertation and can be obtained from University Microfilms.

RESULTS

Factor analysis of the nine lipreading variables separate from the main factor analysis reveals what appears to be a single lipreading factor in each of the three analyses. Two factors were extracted in each analysis but the first factor contained the major proportion of common variance. No meaningful interpretation could be made with respect to speaker-difficulty or structure-of-language. The results of this preliminary analysis of the lipreading criteria suggest that there is only a general factor in lipreading.

Analysis of the Eighth Grade Sample

Thirteen principal components factors were extracted from the fifty-one cognitive ability and lipreading variable factor matrix. Twelve of the 13 extracted factors were rotated to simple structure and positive manifold by verimax procedures. The thirteenth factor had little common variance to contribute to the solution and was not included in the rotations.

Two lipreading factors were isolated in the Eight Grade analysis. Factor A contained two lipreading variables and measures of fluency and flexibility abilities. For example, measures of the cognitive abilities, Ideational Fluency, Associational Fluency, Word Fluency, Expressional Fluency and Semantic Spontaneous Flexibility load significantly on this factor. The several cognitive abilities suggest the rapid, fluent, flexible generation and use of language to underly this factor. Factor A was tentatively identified as Facility with Language.

Factor F contains seven of the nine lipreading variables and measures of Associative (Rote) Memory, Syllogistic Reasoning, Ideational Fluency and sex. The positive loading of sex favors female lipreaders due to the way this variable was scored. Sex was interpreted as Attention to Detail, an ability similar to Perceptual Speed but more comprehensive in nature. Factor F has been identified as a General Lipreading Ability. It contains word, phrase and sentence lipreading variables and easy, average and difficult to lipread speakers.

Of the remaining ten factors in the Eighth Grade analysis, one is a doublet and the remaining nine suggest intellectual abilities in the areas of reasoning, visualization, perceptual speed, memory, and general intelligence.

Analysis of the Eleventh Grade Sample

Fifty-four cognitive and lipreading variables were factor analyzed in the Eleventh Grade analysis. Seventeen factors were extracted and 16 of them were rotated to simple structure and positive manifold. The seventeenth factor would not have contributed significantly to the solution and was omitted from rotations.

Five lipreading factors were isolated in the Eleventh Grade analysis. They have been identified as General Lipreading (Factor B); Word-Phrase Lipreading Ability (Factor I); Word Facility (Factor J); Spatial Detail (Factor N) and Lipreading Reasoning (Factor O). In addition to the General Lipreading Ability isolated also in the Eighth Grade analysis, the Eleventh Grade analysis suggests that there are also specific lipreading abilities for units of language shorter than sentences. The Eleventh Grade analysis also suggests that in addition to facility with language, visual and reasoning abilities are important in lipreading.

Of the remaining eleven factors, three are doublets and one is a singlet. Of the remaining seven factors, one appears to be a general intelligence factor and the other six appear to be the re-definition or re-isolation of well known and well defined abilities.

Adult Female Analysis

Fifty-two cognitive and lipreading variables were analyzed in the Adult Female analysis and thirteen factors were extracted. The thirteen factors were rotated to positive manifold and simple structure by verimax method and four lipreading factors were isolated. The four factors are identified as General Lipreading Ability, Word-Phrase Lipreading Ability, Figural Word Fluency and Lipreading Reasoning. The remaining factors appear to be the re-isolation of commonly known and identified factors.

Summary of Results

Seven lipreading factors were isolated eleven times in the three analyses. The appearance of the same factor in more than one analysis suggests reliable and valid results. The lipreading factors are:

1. General Lipreading Ability (isolated in three analyses)
2. Word-Phrase Lipreading Ability (isolated in two analyses)
3. Lipreading Reasoning (isolated in two analyses)
4. Facility with Language (isolated in one analysis)
5. Word Facility (isolated in one analysis)
6. Figural Word Fluency (isolated in one analysis)
7. Spatial Detail (isolated in one analysis)

With respect to the cognitive abilities loading significantly on lipreading factors, sixteen of the twenty-one hypothesized cognitive abilities (seventeen with sex), loaded significantly 35 times on the factors.

Four fluency factors loaded significantly 12 times on the lipreading factors. They are:

Associational Fluency	Four times
Word Fluency	Four times
Ideational Fluency	Three times
Expressional Fluency	One time
Total	Twelve significant loadings

Five visual cognitive abilities loaded significantly 11 times on the lipreading factors. They are:

Perceptual Speed	Four times
Attention to Detail (sex)	Three times
Length Estimation	Twice
Visualization	One time
Speed of Closure	One time

Total Visual Cognitive Abilities, eleven.

Three reasoning cognitive abilities appear six times in the factor analyses loading significantly on lipreading factors. They are:

Syllogistic Reasoning	Three times
Number Ability	Twice
General Reasoning	One time

Total Reasoning Cognitive Abilities, six.

Three flexibility factors appeared four times on lipreading factors. They are:

Flexibility of Closure	Twice
Semantic Spontaneous Flexibility	One time
Figural Adaptive Flexibility	One time

Total Flexibility Cognitive abilities, four.

Associative (Rote) Memory appeared one time as did Semantic Re-definition.

With respect to lipreading variables, the average difficulty-to-lipread speaker appeared significantly 14 times in the lipreading factors. The easy-to-lipread speaker appeared significantly 13 times on lipreading factors and the difficult-to-lipread speaker appeared 9 times in lipreading factors. Words, as a lipreading variable, appeared a total of 11 times in lipreading factors. Phrases appeared 13 times and sentences as a variable in lipreading appeared 12 times in the analyses. The lipreading variables appeared a total of 36 times in the factor analyses. Phrase Lipreading Test with the easy-to-lipread speaker appeared six times and Word Lipreading Test with the difficult-to-lipread speaker appeared at a total of two times. Lipreading variable representation in the factor analyses are summarized in Table 3.

Table 3

Lipreading Variable Representation in the Factor Analyses by Speaker and Lipreading Test

	Lipreading Tests			
Speaker	Words	Phrases	Sentences	Total[1]
Difficult	2	3	4	9
Average	5	4	5	14
Easy	4	6	3	13
Total	11	13	12	36

[1]Number of times the variable appeared significantly in a lipreading factor.

Communalities used as lower-bound estimates of reliability of the lipreading variables ranged between .33 to .78. Sentence variables were generally more reliable than word variables, but reliability appeared to be influenced by the sample populations of lipreaders. The highest communalities, and hence the best lower-bound estimates of reliability were for the Eleventh Grade sample of lipreaders. The eighth grade and adult female samples had somewhat similar communalities.

DISCUSSION

Word, phrase and sentence lipreading variables appeared equally often, generally speaking, in the three factor analyses. For example, word lipreading variables appeared 11 times in the analyses. Phrase lipreading variables appeared 13 times and sentence lipreading variables appeared 12 times in lipreading factors. This finding is interpreted as a result which does not support the hypothesis that structure of language influences lipreading. That is to say, skill in lipreading should be equally efficient for words, or for phrases or for sentences. The finding, if supported in further studies, has implications for the teaching of lipreading. For example, a variety of lipreading language stimuli should be equally effective for instructional uses, or if certain kinds of language units were preferred, it would for reasons other than their lipreadability.

With respect to ease and difficulty with which a speaker is lipread, there are differences between the difficult-to-lipread speaker, and the other two speakers (easy and average difficulty-to-lipread). The differences are not dramatic however. The difficult-to-lipread speaker appeared nine times in lipreading factors. The average and easy-to-lipread speakers appeared 14 and 13 times, respectively, in the analyses. There is too much evidence of a general lipreading factor which includes all of the lipreading variables, for example, words, phrases, sentences and easy, average and difficult-to-lipread speakers to hold out much support for this hypothesis. The point of view taken by the investigator for the hypothesis with respect to ease and difficulty with which a speaker is lipread is that of suspended judgment.

The hypothesis that age and/or education was influential in lipreading was not supported in this

study. Factor structure varies somewhat from group to group, but there is also surprising communality among the results of the three analyses. Also median lipreading scores for the three sample populations of lipreaders do not differ in a significant and consistent way. Perhaps populations that differ more in age and/or education than the lipreaders in this study would be needed to support this hypothesis.

Regarding lipreading factors, it would appear that General Lipreading Ability, Word-Phrase Lipreading Ability and Lipreading Reasoning are well established in that they were isolated in more than one analysis. In this regard, it would appear that General Lipreading Ability, supported also by the preliminary factor analysis of the nine lipreading variables, is the most firmly established. General Lipreading Ability does not connote that a lipreader will lipread all speakers with equal ease or all language with equal facility. Differences in lipreading speakers and languages will occur but the nature of General Lipreading Ability does suggest that the relative ranking of a lipreader with respect to skill in lipreading will remain constant for lipreading stimuli of differing characteristics.

Lipreading abilities isolated just one time in the three analyses should be regarded as tentative identifications. Subsequent analyses will either support or refute their existence.

With regard to the cognitive abilities hypothesized to be important in lipreading, sixteen (seventeen when sex is included) of the abilities were verified by significant factor loadings on lipreading factors. According to a general classification of the cognitive abilities, visual and fluency cognitive abilities are the most important abilities in lipreading for hearing lipreaders. Reasoning and flexibility cognitive abilities are next most important.

Cognitive abilities appearing most frequently were Associational Fluency, Word Fluency and Perceptual Speed. They appeared four times each in the three analyses. These abilities suggest that fluent word usage and the rapid perception of minute detail are important in lipreading.

Cognitive abilities appearing three times each in the three analyses were measures of Ideational Fluency, Syllogistic Reasoning and Attention-to-Detail or sex. Ideational Fluency is a creative-thinking type of verbal ability. Syllogistic Reasoning is an abstract reasoning ability and sex or Attention-to-Detail is a perceptual ability. Originality in verbal skills together with perceptual and abstract reasoning abilities are suggested as being the underlying variables of importance in lipreading here.

Cognitive abilities appearing twice were Length estimation, a spatial ability, Number Ability, interpreted here as a perceptual ability, and Flexibility of Closure. Space, perceptual and flexibility appear to be important in lipreading for these cognitive abilities.

Although cognitive abilities appearing one time each in the three analyses meet the minimum requirements for inclusion as abilities important in lipreading, it is hoped that they will receive further support in subsequent analyses. The single-appearing cognitive abilities in this study are Expressional Fluency, Visualization, Speed of Closure, General Reasoning, Semantic Spontaneous Flexibility, Figural Adaptive Flexibility, Associative (Rote) Memory and Semantic Redefinition. The study suggests these abilities all have some importance in lipreading.

It is of interest to note that those cognitive abilities associated with language usage appear to be more important in lipreading in contrast to non verbal

skills cognitive abilities, for example, reasoning and visualization. The results suggest that skill in language usage and facility with language is an important variable in lipreading. The results of course suggest that increasing verbal skills would be a way of increasing lipreading skills.

Perceptual abilities are also of importance in lipreading as are reasoning and visual abilities. It would appear that to the extent that these abilities can be developed in the lipreader, to this extent he will be aided in his lipreading.

The results focus on the education of the deaf and suggest that if the deaf person is to become a good lipreader, he must first become skillful in the language he lipreads. This is the area of course where the deaf person is the weakest and the results tend to support the points of view of the oralist school of thought in the education of the deaf.

With respect to experimental design, the study has shown factor analysis to be a useful tool in the study of lipreading. Also supported in this study was the use of part scores of aptitude tests and short lipreading tests. It would appear that the concept that lipreading as a general behavioral phenomenon gained further support from this study.

With respect to the critical question of generalizability of the results of this study to deaf subjects, qualifications must be made. For example, it is the hypothesis of the investigator that the results concerning non verbal cognitive abilities may be generalizable to deaf people. For example, perceptual, reasoning and visual abilities may be found to be important for hearing-impaired lipreaders. On the other hand, it is doubtful that the highly verbal cognitive abilities will be verified by factor analyses which use deaf lipreading subjects.

CONCLUSIONS

This study suggests that a necessary condition but perhaps not sufficient for lipreading is facility with the language lipread. Other conditions are perceptual, reasoning and visual abilities. The results of this study should be generalized to deaf populations for only the non-verbal cognitive abilities found to be important in lipreading. For example, reasoning, spatial and perceptual abilities isolated in this analysis as important in lipreading for hearing lipreaders may also be important for deaf lipreaders. It is probable that the highly verbal skills cognitive abilities will not be found to be important for hearing-impaired lipreaders.

Recommendations

It is recommended that factor analytic studies seek to extend cognitive-ability coverage of lipreading in future studies. Also certain phases of this study should also be verified by subsequent study. With respect to deaf lipreaders, it is probable that Q factor analysis would be most suitable for early investigations. In the Q factor analyses, small groups of homogeneous (with respect to several relevant variables) deaf subjects would be formed and would serve as variables for a variety of cognitive-ability tests. One variable of interest that has not been considered, is difficulty of language as influential in lipreading. Most studies (including this one) carefully minimize language difficult of the lipreading stimulus material. Extension of language difficulty of lipreading stimulus material would in all probability change the factor structure of lipreading especially with respect to verbal comprehension, reading comprehension and other similar variables.

These variables do not load significantly on lipreading now probably because there is no language-difficulty variance. There is the need for a nationally standardized lipreading test. Such normative information is basic to studies of lipreading learning and lipreading achievement. Experimental lipreading studies should probably continue to develop new and novel ways to measure lipreading which will afford the greatest insight into the problem at hand.

SUMMARY

In this investigation, twenty-one cognitive abilities , ease with which the speaker is lipread, structure of the language lipread, age and education of the lipreader and sex were hypothesized as being important in lipreading. Three factor analyses were conducted of lipreading variables and cognitive abilities in order to verify or refute the hypotheses. The influence of age and/or education on factor structure was also examined. Three samples of hearing lipreaders were used in the investigation. They were an eighth grade sample of boys and girls, an eleventh grade sample of boys and girls and an adult female sample of lipreaders.

The factoral analyses isolated seven lipreading factors. They are:

General Lipreading Ability
Word-Phrase Lipreading Ability
Lipreading Reasoning
Facility with Language
Word Facility
Figural Word Fluency
Spatial Detail

Important cognitive abilities in lipreading are fluency and perceptual abilities. Reasoning and flexibility abilities, although of lesser importance than fluency and flexibility abilities, were also found to be important in lipreading. The findings have implications for lipreading teaching.

It is suggested that this study has demonstrated the value of factor analysis in the study of lipreading and it is recommended that further factor analytic investigations of lipreading be undertaken.

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ABSTRACT

800 In a factor analytic investigation of lipreading using normally hearing lipreaders,
801 seven lipreading factors were isolated. The results suggest that there is a
802 general ability to lipread for diverse language and speakers of differing
803 difficulty to lipread as well as specific lipreading abilities. Specific abilities
804 are largely the abilities to lipread words and phrases. Sixteen of 21 cognitive
805 abilities in the areas of spatial, visual, flexibility, reasoning, perceptual
806 and visual hypothesized to be important in lipreading were supported by the
807 factor analytic results. The results suggest that verbal-skills and perceptual
808 cognitive abilities are quite important in lipreading for normally hearing
809 lipreaders. Other cognitive abilities also influential in lipreading are
810 reasoning, flexibility, visual and memory abilities. Because of the heavy
811 emphasis verbal cognitive abilities received in this study, it is felt the
812 investigation supports the oralist's school of thought with respect to the
813 education of the deaf. It was hypothesized that the findings of this study with
814 respect to the non verbal-skills cognitive abilities might have application for
815 hearing impaired-lipreaders but that the findings with respect to the highly
816 verbal cognitive abilities would have little generality for the hearing-impaired.
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